ProbeTip

Seismic signal integration and electromagnetic noise

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Monitoring systems that integrate seismic transducer signals can be susceptible to low frequency electromagnetic noise. An improperly grounded or shielded transducer cable can generate false readings or even false alarms. Therefore, during installation, serious consideration must be given to proper grounding and shielding to protect the system from noise.

A monitor may integrate a velocity or piezo-velocity transducer signal to display displacement rather than velocity units. The monitor becomes vulnerable to low frequency noise because of an intrinsic characteristic of integrators: low frequency signals are amplified more than high frequency signals. If a 5 mV of 50 Hz noise is induced into a 19.7 mV/(mm/s) (500 mV/(in/s)) transducer signal line, after integration a monitor will display 1.6 μm (0.064 mil) of displacement. However, 5mV of 10 Hz noise on the same line, after integration, appears on the monitor as 8.1 μm (0.32 mil) of displacement. The monitor cannot distinguish an electromagnetic noise signal from a velocity signal; it simply converts its input, in velocity units, to displacement, according to the following formula:

$$D = \frac{2000_{(PP)\mu m}}{1_{(PK)mm}} \times \frac{1_{cycle}}{2\pi_{rad}} \times \frac{V_{(PK)mm/sec}}{f_{cycles/sec}} = 318 \times \frac{V}{f}$$

The same conversion applies in English units:

$$D = \frac{2000_{(PP)mils}}{1_{(PK)inch}} \times \frac{1_{cycle}}{2\pi_{rad}} \times \frac{V_{(PK)inch/sec}}{f_{cycles/sec}} = 318 \times \frac{V}{f}$$

where f is frequency in hertz (cycles/sec), V is velocity in millimeters (inches/sec) per second zero to peak, and D is peak to peak displacement in micrometers (mils).

Electromagnetic noise is present in all facilities. The noise could be picked up by an unshielded cable as though it were an antenna. The noise voltage induced into a cable depends on several factors, including the length, shape, conductivity and permeability of the cable. It also depends on the electrical characteristics of the instruments the cable is connected to. Multiple equipment grounds will create ground loops. Differences in electrical potential between those ground points causes noise.
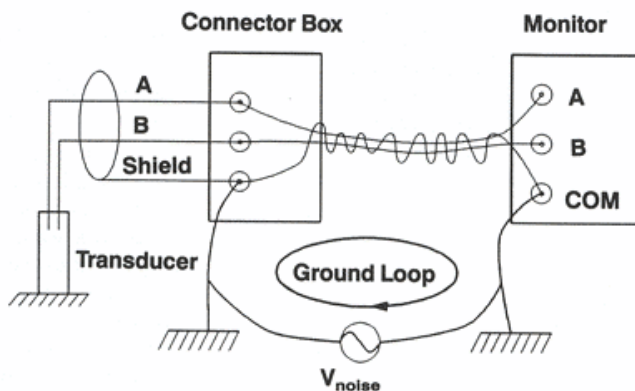

Figure 1

A power plant in northern China offers a good example. A Bently Nevada 3300 System monitors a 100 MW power generator. In addition to proximity and Keyphasor® transducers, six Velomitor® sensors are installed on the generator to measure casing vibration. Bently Nevada's Velomitor sensor is a small, durable Piezo-velocity transducer with no moving parts to wear out. The Velomitor signals are processed and displayed on Bently Nevada 3300/55 Dual-velocity Monitors.

One 3300/55 Monitor, configured with a 10-to-1000 Hz bandpass filter and an integrator with a corner frequency of 2 Hz to integrate the input signals to displacement, experienced a noise problem. The monitor displayed noise levels ranging from 5 to 10 μm (0.20 to 0.39 mil) at all times.

Careful inspection of the Velomitor transducer's signal wiring revealed that a two to three foot length of its cable, at the back of the 3300 Rack, was unshielded. The power generator's strong electromagnetic field induced a noise signal into the unshielded length of cable. This electromagnetic noise was processed by the 3300/55 Monitor as a "true" vibration signal.

After the unshielded cable was replaced, the monitor still displayed 1 to 2 μm (0.039 to 0.079 mil) of noise. We noticed that the Velomitor signal cable went into a connector box, which was grounded, and then went to the monitor rack, which was also grounded. The two grounds created a ground loop (Figure 1), which induced noise into the signal cable. We disconnected the connector box's ground and solved this problem.

Careful attention to velocity transducer signal cable grounding and shielding is important to ensure that monitor measurements are not affected by electromagnetic noise. ■
(See the addendum to this article on page 23)

Addendum to ProbeTip

by Donald E. Bently
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Forces (and moments) of a rotating machine often arise on the rotor itself. The forces are absorbed by inertial elements (masses) and are transmitted to the housing of the machine through the bearings (and somewhat through the seals) and through other rotor/stator interfaces.

Those rotor forces, acting on the housing spring and mass and damping, certainly create housing motion. On most machines, in most circumstances, either the dynamic stiffness of the housing spring or the housing mass is so great that very little housing motion is incurred by the rotor forces or moments. This is often true even when these forces or moments are abnormally large under some malfunction conditions.

Because of this, housing transducers measure motion which is much lower in magnitude than that measured by shaft relative transducers. Therefore, housing transducers observe all the motions transmitted from the various sources in the area, such as cars and trucks, railroad cars, factory equipment, etc. The vital low frequency regions are especially influenced by these external sources.

These external "noises" especially influence the vital low frequency regions, but they may also be present across a wide range of speed. A related source of noise may be another machine nearby with the same rotative speed. This rarely affects a shaft relative probe reading, but may create an inseparable "noise" on a housing measurement.

However, housing motion provides important knowledge of machinery performance, which is valuable for machinery diagnostics and for safety considerations. The vector ratio of the housing to the shaft relative readings at a given location and frequency in the same axis is especially important to machinery diagnostics.■